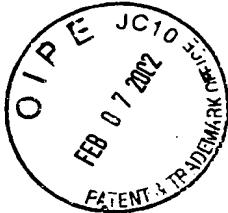**Fully Integrated Critical Care Workstation**

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a non-provisional application claiming priority from provisional application 60/249,572 filed November 5   17, 2000.

FIELD OF THE INVENTION

The present invention relates to a critical-care work-station integrating real-time and non-real-time data displays.

BACKGROUND OF THE INVENTION

10   In a critical-care environment there are many types of information which a doctor may find important in the treatment of a patient. Currently, each type of information is processed by a separate piece of equipment and displayed on a separate display device. This requires a large amount of space around the 15   patient, and requires the doctor to look at many different display devices to acquire all the information desired.

Fig. 1 is a block diagram of an exemplary arrangement of medical devices as just described. In Fig. 1, a plurality 300 of sources of medical information are illustrated. For example, 20   a DICOM archival server computer is a source of medical images, such as X-rays; a hospital information archival server computer is a source of patient history data; and so forth. Each of the plurality 300 of sources includes a corresponding one of a plurality 310 of respective display devices to display the information 25   tion for the doctor. For example, the DICOM archival server computer includes a DICOM viewing display computer operating as a client; and the hospital information archival server computer

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includes a hospital information viewing computer operating as a client; and so forth. Each information server is coupled to corresponding display client via either a direct connection (as illustrated in Fig. 1) or through a network (not shown) in a

5 known manner. The servers 300 and clients 310, in general, store, retrieve and display non-real-time medical information.

The arrangement of Fig. 1 also includes a plurality of sources 320 of real-time medical information, such as electro-cardiogram, blood pressure, blood oxygen level, etc. monitors.

10 In Fig. 1, each such monitor includes electrodes (not shown) in-tended to be connected to the patient, and a monitoring screen (not shown) on which the real-time data collected by the elec-trodes is displayed. This plurality of equipment, along with the display client computers requires a substantial amount of

15 space in the critical care room, and requires the doctor to look at all the different display devices.

More specifically, medical monitoring systems which display images representing real-time physiological functions of a pa-tient are well known. For example, electrocardiogram (ECG) sys-

20 tems receive signals from electrodes attached to a patient and display waveforms representing patient heart function on a dis-play device. Originally, such systems were implemented in hard-wired form, but lately such systems have been implemented by computer systems. These systems include a processor executing a

25 real-time kernel. Real-time application software operates under control of the real-time kernel to receive the ECG electrode signals and to generate signals conditioning the display device to display an image representing the ECG lead waveforms. Such systems are usually specially designed and implemented systems

30 because the real-time kernels are not in general use. Because

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of this, they do not include generally available applications, such as image display applications, or internet web browsers, such as are available on more widely used operating systems, e.g. Microsoft Windows.

5   It has been found, however, that it is often desirable to be able to display both images representing real-time data, such as ECG waveforms, and images representing non-real-time data, such as laboratory results, X-rays, trend data, ventilator loops, etc. One existing system provides two different computer
10   systems, one real-time computer system, such as described above, generating signals representing an image corresponding to the real-time data, and another general-purpose computer system gen- erating signals representing an image corresponding to the non- real-time data. A switch is provided between the two computer
15   systems and the display device, for coupling one of the image representative signals to the display device at a time. In such a system, real-time data is displayed reliably because of the use of the real-time kernel, and display of non-real-time data does not interfere with display of the real-time data because
20   different computer systems are used to control the display of the respective images. However, the doctor may see either the real-time data, or the non-real-time data, but not both simulta- neously.

       Another existing system is designed to display images rep-
25   resenting the real-time data simultaneously with images repre- senting a predetermined set of non-real-time data. For example, such a system may be designed to display ECG images and X-ray images simultaneously. Such a system provides more information to the doctor, but does not permit selection by the doctor of

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desired non-real-time data. Only the non-real-time data de-
signed into the system can be displayed.

A critical-care display system for a critical care room
which provides for the reliable display of real-time data, such

5   as ECG waveforms, simultaneously with selectable non-real-time
data from any available source is desirable. The non-real-time
data may include images generated by specially programmed medi-
cal programs, such as trend data and/or ventilator loop images,
or by generally available programs, such as image display pro-

10   grams, word processors, and/or internet browsers.

BRIEF SUMMARY OF THE INVENTION

In accordance with principles of the present invention, a
critical care workstation includes a display device and a proc-
essor, coupled to the display device. The processor executes

15   both a general purpose operating system controlling execution of
a selected program for displaying images representing non-real-
time data on the display device, and a real-time kernel control-
ling execution of a program for displaying images representing
real-time data on the display device simultaneously with the

20   display of the non-real-time data. In addition, further cir-
cuitry, responsive to user input, selects a non-real-time dis-
play program to execute under the control of the general purpose
operating system from among a plurality of available non-real-
time display programs.

25   ## BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

Fig. 1 is a block diagram illustrating the prior art ar-
rangement for displaying real time and non-real time patient-
related information;

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Fig. 2 is a block diagram illustrating the arrangement for displaying real-time and non-real-time patient-related information according to principles of the present invention;

Fig. 3 is a block diagram of a portion of a critical care workstation according to principles of the present invention; and

Fig. 4 is a block diagram of the software architecture of the software controlling the operation of a critical care work-station according to principles of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 2 is a block diagram illustrating a display device which can display real-time and non-real-time patient related information from a plurality of sources concurrently. Those elements in Fig. 2 which are the same as in Fig. 1 are designated by the same reference numbers and are not described in more detail below.

In Fig. 2, the plurality 300 of sources of medical information are connected to an integrated critical computer worksta-tion 100. The workstation 100 receives the medical information from all of the plurality 300 of sources, and displays that information on a single display device. In addition, the real time patient monitors 320 also provide information to the integrated critical care workstation 100, which displays the real time information concurrently with the other, non-real-time patient information, all as described in more detail below.

As with Fig. 1, although Fig. 2 illustrates direct connection between the plurality 300 of medical information sources and the integrated critical care workstation 100, and between the real-time patient monitors 320 and the integrated critical

care workstation 100, one skilled in the art will understand
that the integrated critical care workstation 100 acts as a cli-
ent for the server computers 300 and the real-time patient moni-
tors 320, and may be connected to them via a network, such as a

5 local area network. One skilled in the art will further under-
stand that more than a single network may be used to connect the
server computers 300 and the real-time monitors 320 to the work-
station 100. For example, one or more networks, designed for
high performance and a short latency time may be used to connect

10 the real-time monitors 320 to the workstation 100, while one or
more slower networks may be used to connect the non-real-time
server computers 300 to the workstation 100. However, the de-
tails of the connections between the server computers 300 and
the workstation 100 and between the real-time monitors 320 and

15 the workstation 100 are not germane to the present invention,
and any appropriate connection may be used.

Fig. 3 is a block diagram of a portion of the critical care
workstation 100 according to principles of the present inven-
tion. In Fig. 3, a processor 10 controls the operation of the

20 critical care workstation 100. An output terminal of the proc-
essor 10 is coupled to an input terminal of a display device 20.
An output terminal of a source 30 of real-time data, such as,
for example, an ECG module, is coupled to a corresponding input
terminal of the processor 10. A mass storage device 40 is cou-

25 pled to the processor 10 via a bi-directional connection. A
network connection 50 is also coupled to the processor 10 via a
bi-directional connection. Although shown as a single connec-
tion, one skilled in the art will understand that the network
connection 50 may be in any of the known configurations, e.g. a

30 LAN, and may also include a bridge (not shown) to a wide area
network, such as the internet. An output terminal of a source

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60 of user input is coupled to an input terminal of the processor 10.

In operation, the real time data source 30, e.g. an ECG module, produces data signals representing, in real-time, the
5 physiological condition of the patient's heart. The processor 10 receives these physiological signals and generates signals representing images corresponding to the physiological signals. The real-time image representative signals are supplied to the display device 20, which displays the images corresponding to
10 the physiological signals. In the illustrated embodiment, the processor 10 executes a real-time kernel. The kernel provides for deterministic execution of a real-time process for receiving the physiological signals from the real-time signal source 30, processing these signals, and generating the image representa-
15 tive signals for the display device 20. For example, for a real-time signal source 30 consisting of an ECG module, signals from the 10 ECG electrodes attached to the patient are received from the real-time signal source 30 and processed by the real-time process in the processor 10 to generate signals represent-
20 ing 12 waveforms corresponding to the 12 lead ECG. Those signals are supplied to the display device 20 which displays the images of these waveforms. The real-time kernel ensures that waveforms representing the 12 lead ECG are displayed reliably within a predetermined latency time.

25 Simultaneously with generating signals representing images corresponding to the real-time data, the processor 10 generates image representative signals corresponding to non-real-time data. Images represented by these signals are displayed on the display device 20 simultaneously with the real-time images de-
30 scribed above. In the illustrated embodiment the processor 10

executes a generally available windowing operating system, e.g.
Microsoft Windows or an Apple Macintosh OS, simultaneously with
and independent from the real-time kernel. A non-real-time ap-
plication program executes under the control of the windowing
5   operating system. Examples of such a non-real-time application
program are an internet web browser, a word processor or an im-
age display program.

More specifically, code and data for one or more non-real-
time application programs is stored on the storage device 40 or
10·   on a server (not shown) on the LAN 50 and/or internet (not
shown). A user supplies data to the processor 10 selecting one
of the available non-real-time application programs via the user
data source 60. The processor 10 retrieves the code and data
for the selected non-real-time application program and executes
15   the application program under control of the windowing operating
system. For example, the selected application program may be an
image display application which can retrieve data representing
an image, such as an X-ray image from the DICOM archival server
computer (of Fig. 1), and produce signals conditioning the dis-
20   play device 20 to display the X-ray image on the display device
20.

Fig. 4 is a block diagram of the software architecture 20
of the software controlling the operation of a critical care
workstation according to principles of the present invention.
25   In Fig. 4, a common operating system kernel 202 provides serv-
ices to programs executing on the processor 10 (of Fig. 3). For
example, the common OS kernel 202 provides information relating
to available memory, virtual memory, input/output (I/O), etc.
The windowing operating system executes as a first process on
30   the processor 10. This is illustrated on the right hand portion

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of Fig. 4. An application program interface (API) 204 provides
a simplified way for a non-real-time application program 206 to
access the functions provided by the common OS kernel 202. A
human interface layer 210 provides a simplified way for the non-

5   real-time application program 206 to generate display images for
the display device 20. The human interface 210 conditions the
processor 10 to generate image representative signals in re-
sponse to the non-real-time application program 206. As de-
scribed above, these signals are supplied to the display device

10   20 which displays the image represented by those signals.

A real-time kernel executes as a second process on the
processor 10. This is illustrated on the left hand portion of
Fig. 4. A real-time process 212 also receives services from the
common OS kernel 202. The real-time kernel in the real-time

15   process 212 provides deterministic execution of the real-time
process 212. The real-time process 212, in turn, conditions the
processor 10 to receive the real-time signals from the real-time
signal source 30, process the real-time signals, and generate
image representative signals corresponding to the real time sig-

20   nals. As described above, these signals are also supplied to
the display device 20, which displays the image represented by
these signals simultaneously with the image represented by the
non-real-time signals. One skilled in the art will further un-
derstand that the style of the image displayed by the real-time

25   process 212 may be made similar to, or the same as, the style of
the image displayed by the non-real-time application program 206
as controlled by the human interface 210.

A system according to Fig. 3 and Fig. 4 allows images cor-
responding to real-time data to be displayed concurrently with

30   images corresponding to non-real-time data from a plurality of

sources. In addition, the non-real-time data may be generated
by any application program which may be executed under the con-
trol of the windowing operating system. Because a windowing op-
erating system is more commonly available, a wider variety of

5   non-real-time application programs are available to the user and
any such program which is made available either on the storage
device 40 or on the LAN 50 or internet (not shown) may be se-
lected to be executed.